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Denville, New Jersey

16 Project 5513

6 PRESSURE-THRUST RELATIONSHIPS OF VISCO-ELASTIC FLUIDS.

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1. INTRODUCTION

9 This report is the first bimonthly progress report on Contract DA 18-108-AMC-130(A), Pressure-Thrust Relationships of Visco-Elastic Fluids ~~(RMD Project No. 5513)~~. This work represents a continuation and extension to actual experimentation of theoretical studies conducted under Contract DA 18-108-405-CML-891. We will study the physical parameters of gas pressurization (and expulsion) of a visco-elastic fluid (thickened gasoline), and the related problems of means of pressurization and of recoil compensation.

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As a result of ~~the~~ theoretical studies performed previously ~~under the previous contract cited above,~~ pressurization by means of hot combustion gases was selected for investigation. ~~From the earlier work,~~ a liquid bipropellant gas generator utilizing nitrogen tetroxide (~~N_2O_4~~) and unsymmetrical dimethylhydrazine (~~UDMH~~) as oxidizer and fuel, respectively, was chosen as being representative of a class of controllable-output hot gas pressure sources. An alternative approach to a source of pressurization and counterrecoil thrust was a solid-propellant rocket with a coolant-diluent bed between the rocket and the flamethrower fuel tank. This configuration will be evaluated concurrently with the liquid bipropellant system.

Progress to date on these two candidate systems are discussed below in two separate sections. In addition, preparation of a firing site for operation of the flamethrower research device at ranges up to 150 yards is discussed in a third section.

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2. LIQUID BIPROPELLANT GAS GENERATOR

The liquid propellant approach to using combustion processes for gas generation in a flamethrower application has proceeded well into the testing phase during the reporting period.

The selection of UDMH and N_2O_4 as propellants was made on the basis of ease of handling, storability, safety considerations, and because of the reliable hypergolicity of the combination. Testing has not revealed any ignition problems, there have been no undesirable transient phenomena even at extreme mixture ratios and only the production of slight residues is a matter of present concern from the standpoint of possible overhaul requirements when the unit is serviced between firings.

Previous tests with N_2O_4 and UDMH had established relationships between mixture ratio, combustion gas temperature and c*. These parameters were used as a basis for designing a gas generator which would nominally produce 450 psi fuel-rich gases at 1000°F at a rate of .16 lb/sec. These values would be adequate to expel two gallons per second of gelled gasoline from a flamethrower.

Two injectors have been fabricated and one has been tested. The first has four fuel streams impinging on a single center oxidizer stream. The second injector has a single fuel stream impinging with a single oxidizer stream at approximately optimum mixture ratio. Four additional fuel streams which provide the balance of the fuel impinge further downstream to cool the burning mixture to desired values.

Any combination of injector, combustion chamber, nozzle, or accumulator can be assembled and tested to determine optimum operating conditions.

Because of the extremely small oxidizer flow rates, about .015 pound per second, a cavitating venturi could not easily be constructed. Instead, a differential pressure orifice meter has been employed in the initial tests to measure flow rates which have been controlled by the overall system pressure drop. Thus, oxidizer flow rate varies with chamber pressure fluctuations in the present test setup. When chamber pressure is low, the N_2O_4 flow rate will be a maximum and as chamber pressure increases, oxidizer flow rate will approach its design value. Starting transients are thus minimized at the expense of slight pressure fluctuations.

A minor problem in the testing program has been the measurement of combustion gas temperature. Measurements taken at various locations in the combustion chamber with shielded chromel-alumel thermocouples have been consistently lower than expected. However, temperatures measured in a 225 cubic inch accumulator connected directly to the combustion chamber have varied from 800°F to 1200°F as mixture ratio was varied from .04 to .08. These temperatures are slightly higher than desirable and have been reduced in two tests by installing an orifice between the combustion chamber and accumulator.

The low temperatures measured in the small volume combustion chamber are not realistic combustion gas temperatures but probably represent the temperature of the liquid-vapor mixture of UDMH at chamber pressures under the fuel-rich operating conditions.

Two different pressure switches have been employed to automatically maintain a minimum pressure in the 225 cubic inch accumulator. As the pressure decreases to the lower limit, the propellant valves open until such time that the upper pressure limit is reached, whereupon the propellant flow is stopped.

To simulate an increasing ullage volume in the flamethrower as gelled gasoline is expelled, orifices were used on the accumulator outlet.

With the first switch, pressures were maintained between 250 and 500 psi. Average temperatures were lowered some 300°F from continuous operation at the same flow rates. A second switch maintained pressures between 440 and 550 psi. Again, gas temperatures were considerably reduced from steady state operation.

When the pressure is varied slowly, the second pressure switch can maintain a differential of 60 psi. Although combustor tests have not yet been run under constant volume, no flow conditions, it is believed that a pressure can be maintained with relatively small variation with a switch similar to that being presently used.

The combustor has been started against back pressure as high as 512 psi with no difficulties experienced.

It has been noted that a black residue has been formed at times. The extent and conditions under which this formation takes place will be explored during the next report period.

When these tests have been completed, it is planned to install the gas generator on the government-furnished gelled gasoline tank and initially expel water through the flamethrower nozzle to check out gas generator operation and control under simulated expulsion conditions. The purpose of these tests is to determine the transient characteristics of the system for integration with the flamethrower and the recoil rocket in subsequent breadboard system tests.

3. SOLID PROPELLANT-ACTUATED RECOIL-COMPENSATED WORKHORSE FLAMETHROWER

This solid propellant-actuated long-range flamethrower is a workhorse version of the device described to Messrs. Chernack, Penn, and Beyth and Major Yusas during the visit of E. Klaubert to Edgewood Arsenal, CRDL, on April 4-5, 1963. It is intended to permit evaluation of the comparative advantages and problems of using a one-unit solid propellant counterrecoil rocket (CRR) and pressurization gas generator (GG) vs. a dual-combustor liquid bipropellant CRR/GG system.

To date, drawings have been completed for all components of this solid propellant workhorse unit. Propellant casting hardware for the solid propellant charges which will be used in the workhorse unit has been fabricated; but application of the silicone mold release resin, which must be done before grains can be prepared, has been held up. The delay has been due to apparent loss in transit by Railway Express of the order of mold release resin. The material has been reordered, and an interim quantity of sample containers has been delivered by Air Express (the material's ICC classification is red label, and thus bulk quantities cannot be shipped by air). Coating of the casting fixtures is in process, and propellant grain fabrication should begin within two weeks.

Meanwhile the workhorse CRR motor components, and also most of the parts of the workhorse flamethrower, have been fabricated. Since this unit is not adaptable to proper mounting on the thrust carriage of the flamethrower research device, a

flexure-supported thrust mount has been designed. This thrust mount will attach to the machine gun tripod of the flamethrower research device, and will use the same thrust dynamometer. Fabrication of this thrust mount will begin very shortly.

Initial quantities of pressed pellets of ammonium chloride (NH_4Cl) have been prepared. This material will be used as a coolant-diluent to reduce the temperature of pressurizing gas from ca. 4600°F (chamber flame temperature) to 600-800°F before entering the gelled fuel tank. These pellets were pressed to nearly theoretical density (1.49-1.51 g/cc vs. theoretical 1.53 g/cc) in sizes of 1/8, 3/16, and 1/4" diameter (approximately 1 diameter in length) using available tablet press and dies.

4. FLAMETHROWER FIRING RANGE

A site has been selected for the flamethrower firing range, and contractors have been authorized to proceed immediately with the necessary site preparation. The site is at the Secondary Waste Disposal Area ("burning ground") of RMD's Test Area R. This location presently affords a cleared, and very nearly flat, area approximately 150 yards long by 75-100 yards wide. A portion of one end of this clearing will be extended to afford a maximum range of ca. 200 yards in order to provide some over-travel protection. A steel gun turret will be installed on a concrete pad at one end of the range, very close to the end of the clearing, and the flamethrower will be mounted inside this turret. Thus, in the unlikely event of a fuel tank or fuel line rupture, the resultant splash of burning fuel will be confined. An available trailer will be installed adjacent to the turret to house instrumentation, service, and range engineering activities.

Site preparation is expected to be completed by shortly after mid-June.